PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P/62322/GPTU18		

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB 03/02508	11.06.2003	11.06.2002

International Patent Classification (IPC) or both national classification and IPC

H04J14/02

Applicant

MARCONI UK INTELLECTUAL PROPERTY LTD. et al

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 8 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10.12.2003	06.08.2004

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB 03/02508

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

4-8	as originally filed
1-3, 3a	received on 01.06.2004 with letter of 26.05.2004

Claims, Numbers

1-23	received on 01.06.2004 with letter of 26.05.2004

Drawings, Sheets

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3-11, 14-23
	No:	Claims	1, 2, 12, 13
Inventive step (IS)	Yes:	Claims	
	No:	Claims	3-11, 14-23
Industrial applicability (IA)	Yes:	Claims	1-23
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

   D1: EP-A-0 924 888 (NORTHERN TELECOM LTD) 23 June 1999 (1999-06-23) cited in the application
   D2: WO 02 09299 A (SYCAMORE NETWORKS INC) 31 January 2002 (2002-01-31) cited in the application
   D3: EP-A-0 543 570 (AMERICAN TELEPHONE & TELEGRAPH) 26 May 1993 (1993-05-26)
   D4: DE 198 48 989 A (SIEMENS AG) 11 May 2000 (2000-05-11)

2. The present application does not meet the requirements of Art. 33(2) PCT, because the subject-matter of **claims 1, 2, 12 and 13** is not new.

2.1 Document D1 discloses following features (applying the terminology of independent **claim 1**):

> A method of controlling signal launch power of at least one optical signal in an optical communications network (Fig. 1), comprising pre-distorting the launch power of the optical signal (page 5, paragraph 21) in accordance with a known value of the bandwidth of a modulation signal used to modulate the optical signal (page 5, paragraph 21; The mentioned channels carry signals of different bit rates, i.e. having different modulation bandwidths. Therefore the predistortion of each signal depends on its modulation bandwidth).

This is the complete wording of claim 1 the subject-matter of which consequently cannot be acknowledged as being novel.

2.2 The features of **claim 2** are also disclosed by document D1 (page 4, paragraph 17) and therefore not new.

2.3 **Claims 12 and 13** represent the apparatus claims corresponding to the features of the method claims 1 and 2, respectively. Consequently, the above reasoning applies to claims 12 and 13, too, yielding a lack of novelty.

3. The features of dependent **claims 3-11 and 14-23** are either disclosed or rendered obvious by documents D1-D4. Therefore, the subject-matter of these claims is not regarded as being inventive.

OPTIMISING POWER IN OPTICAL COMMUNICATIONS NETWORKS

This invention relates to optical communications networks, and in particular to optimising power available to launch signals onto optical communications networks.

The design of photonics systems requires that the OSNR (optical signal to noise ratio) is above a given minimum value over the longest path under the worst case conditions.

Optical communication systems, such as wavelength division multiplex (WDM) systems typically use optical amplifiers in the signal path. A limiting feature of optical amplifiers is the power available. This may be due to safety constraints or cost. The maximum output power of an optical amplifier is conventionally divided equally amongst all the optical channels being transmitted.

However, higher bit rate channels such as 10Gbit/s require a better OSNR than lower bit rate channels such as 2.5Gbit/s channels.

It has been proposed (EP-A-0 924 888) to adjust the optical power in individual channels by measuring optical power along the transmission path in use. However, the processing overload for this is relatively high.

Also, it has been proposed (WO 02/09299) to compensate for wavelength dependent gain and noise profiles by pre-emphasising individual channels of a WDM by values obtained by measuring the OSNR of the undistorted channels.

The invention aims to maximise the power available to optical signals requiring a higher bandwidth and/or greater path length. Broadly, this is achieved by dividing available output power amongst the optical channels according to their individual bandwidth/distance requirements.

More specifically, there is provided a method of controlling signal launch power of at least one optical signal in an optical communications network, comprising pre-distorting the launch power of the optical signal in accordance with a known value of the bandwidth of a modulation signal used to modulate the optical signal.

The invention also provides apparatus for controlling signal launch power of at least one optical signal in an optical communications network, comprising a launcher for launching the optical signal onto the network, and means for pre-distorting the launch power of the optical signal in accordance with a known value of the bandwidth of a modulation signal used to modulate the optical signal.

This has the advantage that launch power of a first optical signal can be conserved and redirected to a second optical signal whose associated modulation signal has a greater bandwidth than the modulation signal associated with the first optical signal, without incurring a processing overload due to making measurements.

Preferably, the optical communications network carries an n channel signal multiplex, and a plurality of optical signals are launched from a network node.

Preferred embodiments have the advantage that for a given launch power available at an add/drop node, the power can be distributed amongst the channels in accordance with the requirements of each channel. This again can increase the bandwidth that can be sent and increase the transmission distance that can be achieved.

The noise is generated at the optical amplifiers, and the expected noise can be determined knowing the route of the optical signal, that is, the number and type of optical amplifiers the optical signal will pass through in the network. This will be indicative of the OSNR. The known values may be provided by management systems of the optical communication systems, for example, by the network manager, or by a shelf

manager. Equally, the known values may be provided by data passed along a supervisory channel.

In a preferred embodiment, the pre-distorted optical signals are passed though an optical amplifier, and the launch power is pre-distorted using a comparator. A separate comparator is provided for each channel of the optical multiplex, a suitable de-multiplexer being provided at the output of the optical amplifier. One input to the comparator is a signal, preferably electrical, derived from the output of the optical amplifier for any particular optical channel, while the other is representative of the known value of the bandwidth of the modulation signal associated with the optical signal. The output of the comparator controls the launch power of the optical signal for that channel into the optical amplifier, for example, by means of a variable optical attenuator for a through channel, or a transponder for an added channel.

An embodiment of the invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram illustrating the principle of the invention;

Figure 2 is a schematic diagram showing how launch power can be adjusted according to the connection path; and

Figure 3 shows the invention applied to an optical ring network.

The embodiments described divide the available output power amongst the channels according to individual bandwidth requirements. The higher the bit rate, the higher the power level allocated to that channel ensuring that all channels are launched such that they are received with adequate OSNR.

The power output for a given channel can also be controlled according to the number and type of network elements the signal is to pass through.

Referring to Figure 1, an optical amplifier 10 amplifies a WDM optical signal on a fibre 11. The output is split at a coupler 12 providing an output signal path 13 and a

CLAIMS

1. A method of controlling signal launch power of at least one optical signal in an optical communications network, comprising pre-distorting the launch power of the optical signal in accordance with a known value of the bandwidth of a modulation signal used to modulate the optical signal.
2. A method as claimed in Claim 1, further comprising pre-distorting the launch power of the optical signal in accordance with a known value of expected noise on the signal path of the optical signal.
3. A method as claimed in claim 2, wherein the known values are provided by management systems of the optical communication network.
4. A method as claimed in claim 3, wherein the known values are provided by a network and connectivity information unit.
5. A method as claimed in claim 3, wherein the known values are supplied by a supervisory channel.
6. A method as claimed in any one of claims 1 to 5, wherein each pre-distorted optical signal is passed through an optical amplifier.
7. A method as claimed in claim 6, wherein the signal launch power of an optical signal is pre-distorted using a comparator, which compares a signal derived from the output of the optical amplifier with a reference signal dependent on a known value of the bandwidth of a modulation signal used to modulate the optical signal.
8. A method as claimed in any one of claims 2 to 7, in which a known value for expected noise on a signal path of an optical signal is derived from a knowledge

of the number and type of optical amplifiers an optical signal will pass through in the optical communications network.

9. A method as claimed in any one of claims 1 to 8, in which the optical communications network carries an n channel multiplex, the launch powers of at least one of the optical signals is pre-distorted by an optical amplifier.

10. A method as claimed in any one of claims 1 to 9, in which the launch power of an optical signal with an associated modulation signal of a higher bandwidth is pre-distorted to increase the signal level of the optical signal compared to an optical signal with an associated modulation signal of a lower bandwidth.

11. A method as claimed in any one of claims 2 to 10, in which the launch power of an optical signal is pre-distorted to increase the signal level of the optical signal when the expected noise on the signal path of the optical signal through the network is higher compared to an optical signal having a lower then expected noise on its signal path through the network.

12. Apparatus for controlling signal launch power of at least one optical signal in an optical communications network, comprising a launcher for launching the optical signal onto the network, and means for pre-distorting the launch power of the optical signal in accordance with a known value of the bandwidth of a modulation signal used to modulate the optical signal.

13. Apparatus as claimed in claim 12, wherein the means for pre-distorting the launch power of the optical signal is also arranged to pre-distort the launch power of the optical signal in accordance with a know value of expected noise on the signal path of the optical signal.

14. Apparatus as claimed in claim 13, wherein the known values are provided in use by management systems of the optical communication network.

15. Apparatus as claimed in claim 14, wherein the known values are provided by a network and connectivity information unit.

16. Apparatus as claimed in claim 14, wherein the known values are supplied by a supervisory channel.

17. Apparatus as claimed in any one of claims 12 to 16, including an optical amplifier through which pre-distorted optical signals are passed in use.

18. Apparatus as claimed in claim 17, wherein the pre-distorting means for an optical signal includes a comparator, arranged to compare a signal derived from the output of the optical amplifier with a reference signal dependent on a known value of the bandwidth of a modulation signal used to modulate the optical signal.

19. Apparatus as claimed in any one of claims 13 to 18, in which the number and type of optical amplifiers an optical signal will pass through in the optical communications network is used to derive the expected noise on the signal path of the optical signal.

20. Apparatus as claimed in any one of claims 12 to 19, in which the optical communications network is adapted to carry an n channel multiplex, the launch powers of at least one of the optical signals is pre-distorted by an optical amplifier in use.

21. Apparatus as claimed in any one of claims 12 to 20, in which the pre-distorting means is arranged to increase the signal level of an optical signal with an

associated modulation signal of a higher bandwidth compared to an optical signal with an associated modulation signal of a lower bandwidth.

22. Apparatus as claimed in any one of claims 13 to 21, in which the pre-distorting means is arranged to increase the signal level of an optical signal having a higher than expected noise on its signal path through the network compared to an optical signal having a lower then expected noise on its signal path through the network.

23. Apparatus as claimed in any one of claims 12 to 22, in which the apparatus is an add/drop node